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Delayed chest closure after lung transplantation: Techniques, outcomes, and strategies

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BACKGROUND: Delayed chest closure (DCC) after lung transplantation is a viable option to be taken in the cases of prolonged cardiopulmonary bypass time, prolonged ischemic time, coagulopathic problems or oversized donor lung grafts. Decision-making for DCC in the operating room remains challenging to surgeons, because the impact of DCC on outcomes after lung transplantation has not yet been fully elucidated.

METHODS: We performed a retrospective review of 90 lung transplantations with DCC and 783 cases with primary chest closure to clarify the reasons for DCC, complications of DCC, and the risk factors for adverse outcomes.

RESULTS: The 30- and 90-day mortality in the DCC group was 7.8% and 9.9%, respectively. Early post-operative bleeding and severe primary graft dysfunction (PGD) were higher in the DCC group ($p < 0.05$). In multivariate analysis, prolonged cardiopulmonary bypass use (>4 hours), post-operative extracorporeal oxygen requirement and use of a DCC technique with open skin and retracted ribs were significantly associated with mortality ($p < 0.05$), whereas prolonged duration of DCC was not. In a matched cohort study to compare the results of a DCC technique with skin closure to similarly matched controls with primary closure, DCC contributed to significantly decreased incidence of severe PGD (9.6% vs 26%, $p < 0.05$), leading to an improved post-transplant survival and functional status as compared with primary closure.

CONCLUSIONS: Our technical approaches to prevent possible problems in DCC cases are described. DCC can be safely performed with acceptable procedure-related risks. DCC should not be considered a sub-optimal option after lung transplantation.

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With recent refinements in operative techniques and improvements in organ protection and post-operative care, lung transplantation has evolved into an established treatment for end-stage lung disease.[1] However, primary graft dysfunction (PGD) remains the main cause of early morbidity and mortality after transplantation and typically occurs within the first few days after the lung transplant.[2–5] Surgeons must make every effort at the time of surgery to minimize PGD incidence and prevent any ongoing acute lung injuries from being aggravated in the operating room. Excessive compression to lung allografts with ongoing lung

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injuries or a dilated right ventricle because of an inappropriate decision to close the chest may exacerbate lung injuries or right ventricular dysfunction, leading to PGD and/or irreversible lung allograft dysfunction.

Open chest management with delayed chest closure (DCC) has been an established therapeutic option in cardiac surgery and heart transplantation since the 1970s, with a robust literature supporting the strategy to date.[6–9] In contrast, only a few reports have speculated on the role and early outcomes of DCC after lung transplantation.[10,11] Although DCC has been a relatively common strategy used by lung transplant surgeons, the techniques, indications and outcomes of DCC in the setting of lung transplantation have not been fully elucidated. As one of the largest lung transplant centers in the USA, we have liberally used DCC in surgically challenging cases. In this study we reviewed our large experience of DCC in lung transplantation to better understand the indications for DCC and the outcomes after using DCC in the lung transplantation setting.

Methods

Patients

Human subject approval for this study was obtained from the University Pittsburgh Medical Center institutional review board (Approval No. 0000731). From January 2004 to December 2011, we performed primary lung transplantation in 873 patients with end-stage lung disease, exclusive of heart–lung and redo lung transplantation cases. Of these, 90 patients (10.3%) underwent DCC after lung transplantation (DCC group). The initial decision for DCC was made by the attending surgeons who performed the transplantation, primarily based on the hemodynamic stability, coagulopathy, lung graft function/compliance or size-matching of lung grafts. The outcomes of the patients with DCC after lung transplantation were compared with those of patients without DCC ($n = 783$). We also divided the patients who underwent DCC into 3 subgroups based on the closure techniques used for their DCC and further analyzed the post-operative outcomes in each subgroup. In all patients, lung transplantation was performed using standard techniques and our current lung protection protocol, which have been reported in detail elsewhere.[12,13] A standardized care pathway for post-operative care was also utilized in all patients.

Intra-operative details, complications, mortality and long-term survival

Data regarding the intra-operative details and post-operative complications were collected from the database of the UPMC Transplant Patient Management System, which documents all adverse outcomes via prospective data collection from patients' clinical records. The requirement of blood products was expressed as the total number of units of red blood cells (RBC), packs of fresh frozen plasma, and bags of platelets required during surgery and for the first 48 hours after surgery.

Short-term complications included post-operative bleeding requiring re-exploration, respiratory failure requiring an extended period of ventilator management (≥ 5 days), renal insufficiency requiring hemodialysis, and severe PGD requiring extracorporeal membrane oxygenation (ECMO). Renal dysfunction was defined as severe renal insufficiency requiring either temporary or permanent dialysis treatment. PGD and acute rejection were defined and graded using the ISHLT definitions.[2] Screening transbronchial biopsy after lung transplantation was performed 2 weeks after the surgery and every 2 months subsequently. Acute cellular rejection was diagnosed based on the results of transbronchial biopsy, and acute rejection was defined as Grade A2 rejection or greater that was treated with steroid pulse therapy.

With our protocol, pulmonary function tests (PFTs) are routinely performed at 1, 3, 6 and 12 months after lung transplantation, then yearly thereafter until 5 years after transplantation. Additional testing was performed based on clinical necessity. In this study, the peak post-transplant forced expiratory volume in 1 second (FEV_1) and 6-minute walk test (6MWT) values available from the routine PFTs were used to assess of the quality of the graft. Long-term clinical outcomes were assessed by overall survival 5 years after transplantation.

Techniques of DCC and post-DCC management protocol

We used three different techniques for DCC depending on the size of the lung allografts and the patient's hemodynamics: (1) superficial structures including skin and subcutaneous tissue were closed but the ribs were left unapproximated (DCC-1; Figure 1A); (2) superficial structures were left open and covered with a medical bandage (Esmark, Medical Industries, Inc., Mundelein, IL), and the ribs were left unapproximated (DCC-2; Figure 1B); and (3) superficial structures were left open, and a chest retractor was used to keep the ribs open (DCC-3; Figure 1C).

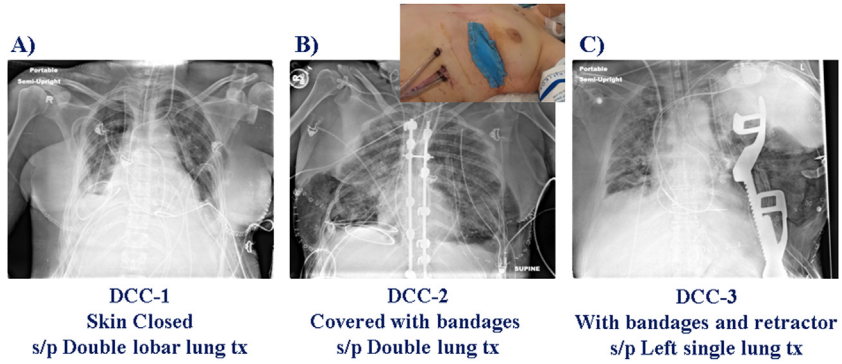

Figure 1 Three different types of DCC techniques after lung transplantation are shown in chest X-rays: (A) DCC-1: superficial structures including skin and subcutaneous tissue were closed but the ribs were left unapproximated. (B) DCC-2: superficial structures were left open and covered with medical bandage (Esmark, Medical Industries, Inc., Mundelein, IL; blue bandage shown in a small picture on the right top). (C) DCC-3: superficial structures were left open and chest retractor was also used to keep the ribs open.